

Effect of Wrist Joint Restriction on Forearm and Shoulder Movement during Upper Extremity Functional Activities

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Abstract. [Purpose] This study measured %isolation and investigated whether it shows a difference between the presence and absence of wrist joint restriction, as well as changes in muscle activity patterns. [Methods] Twenty subjects performed upper extremity functional movement in the Manual Function Test (MFT) with and without wrist restriction, and the muscle activities of the trapezius, middle deltoid, biceps brachii, triceps brachii, extensor carpi radialis, and flexor carpi radialis were recorded. When there were differences in muscle activation, %isolation was implemented and the changes in the muscle activity patterns were noted. [Results] In the grasping and pinching tasks, there was a significant increase in %isolation of the upper trapezius and a significant decrease in %isolation of the extensor carpi radialis. Carrying a cube task, %isolation of the upper trapezius and middle deltoid significantly increased, whereas %isolation of the triceps brachii and extensor carpi radialis significantly decreased. In the pegboard task, the %isolation values of the extensor carpi radialis and flexor carpi radialis significantly decreased. [Conclusion] The data of this study should be useful for therapists, who can employ the information as material for the education and treatment of patients with wrist joint restriction. Therapists may thus look for ways to improve the quality of mobility by predicting the complement mobility depending on the activity performed and then determine whether to facilitate or restrict mobility.

Key words: Functional upper extremity activity, %isolation, Wrist joint restriction

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INTRODUCTION

One of the goals of occupational therapy is to help improve the performance of functional tasks in daily life¹⁾. In particular, hand and upper extremity activities play an important role in tasks of daily living such as dressing, using a keyboard, eating and so forth²⁾. One of the important systems involved in functional tasks of the hand and upper extremity is the mobility of the wrist. The wrist consists of the ulna, radius, and eight carpal bones. It is a complicated structure consisting of a number of ligaments and muscles³⁾. The wrist uses various movements such as flexion, extension,

ulnar deviation, and radial deviation; pronation and supination may also be used in coordination with the elbow joint⁴⁾.

The complicated structure and high mobility of the wrist often results in various types of disorder. Wrist joint restriction affects the movement of other joints and causes subsequent problems such as pain. Such problems affect the upper extremity functional activities, which are important goals of occupational therapy. Hence, it is necessary to objectively evaluate the changes in mobility that might take place due to wrist joint restriction during upper extremity functional activities.

The %isolation method can be implemented to examine the pattern of muscle changes due to wrist joint restriction. Since muscle activation may result from reflex activity and fatigue as well as muscle contraction⁵⁾, measuring the changes in %isolation of muscles demonstrate how wrist joint restriction changes muscle patterns during upper extremity functional activities.

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This study measured the %isolation in upper extremity functional movements related to wrist joint restriction in order assess changes in mobility of the shoulder, forearm and wrist.

SUBJECTS AND METHODS

The purpose and procedure of the study were fully explained to students at S college, Suncheon, Jeonnam. We then included 20 individuals (15 women and 5 men) in the study who agreed to participate in the experiment and signed the consent form. The chosen subjects were all right-handed, and had neither congenital malformation of the upper extremity nor past functional disorder of the wrists or upper extremities. They had no medical history in terms of orthopedics, neurology, or pathology. All the participants read and signed an informed consent form, and the Inje University Ethics Committee for Human Investigations gave ethical clearance prior to their participation. This study was performed from February 25, 2012 to March 10, 2012. The experiment was conducted in a laboratory equipped with an electromyograph.

BTS FreeEMG 300 (BTS, Inc., Milan, Italy), a surface wireless electromyography system was used to measure muscle activation. It has eight electromyogram (EMG) channels and uses Wi-Fi technology for wireless data transmission. To examine the muscle activation with and without wrist joint restriction, electrodes were attached to the upper trapezius, middle deltoid, biceps brachii, triceps brachii, flexor carpi radialis, and extensor carpi radialis⁶⁾. In attaching the surface electrodes, the procedures used by Cram, Kasman and Holtz⁷⁾ were adopted at the electrode locations. Hair was removed using a razor blade to minimize skin resistance to electromyographic signals, and the area was washed with disinfectant alcohol twice or three times to remove the horny layer. The same person attached all the electrodes.

The wrist orthosis used for wrist joint restriction was a commercially available, portable, short-wrist orthosis (SP-872) which is used to minimize wrist joint movement to prevent and heal pains generated by various wrist disorders (Special Protectors Co., Inc., Taipei, Taiwan).

This study employed manipulation activities that directly involve the wrist joint in the Manual Function Test (MFT) to evaluate upper extremity functional activities. MFT is a standardized tool that was developed to evaluate damaged motion functions of the upper extremity and objectively analyze the recovery process⁸⁾, and it is the most frequently used tool of its kind in Korea⁹⁾. The evaluation order and instructions were based on the standardized method of the MFT.

The %isolation indicates the role of each muscle as a percentage of the total activity of all the muscles used in the task. It measures the extent of muscle operation during a given task. For example, if the %isolation value of the upper trapezius was 100%, it would mean that the other muscles did not work at all during the task. The %isolation was calculated using the following formula¹⁰⁾.

$$\text{Isolation}_{xyi}(\%) =$$

$$\left[\frac{\text{EMG}_{xyi}}{\text{EMG trapezius}_{yi} + \text{EMG middle deltoid}_{yi} + \text{EMG biceps}_{yi} + \text{EMG triceps}_{yi} + \text{EMG wrist extensor}_{yi} + \text{EMG wrist flexor}_{yi}} \right] \times 100$$

SPSS 12.0 version was used for the statistical processing for the data analysis in this study. The general characteristics of the subjects were analyzed using descriptive statistics. Wilcoxon's test was employed to analyze changes in %isolation between with and without wrist joint restriction in the MFT tasks. The significance level, α , was 0.05.

RESULTS

In the grasping task, changes in %isolation of the muscles were shown between with and without wrist joint restriction (Table 1). Without wrist joint restriction, the %isolation of the upper trapezius was $35.57 \pm 12.21\%$, and it increased significantly to $40.93 \pm 19.78\%$ ($p < 0.05$) with wrist restriction. In contrast, the %isolation of the extensor carpi radialis decreased significantly from $22.75 \pm 11.39\%$ without wrist joint restriction to $15.19 \pm 7.04\%$ with wrist joint restriction ($p < 0.05$). In the pinching task, changes in the %isolation of muscles were observed between with and without wrist joint restriction (Table 2). Without wrist joint restriction, the %isolation of the upper trapezius was $25.26 \pm 20.06\%$, whereas with wrist joint restriction, it significantly increased to $39.72 \pm 32.69\%$ ($p < 0.05$). In contrast, the %isolation of the extensor carpi radialis without wrist joint restriction changed significantly from $17.03 \pm 8.17\%$ to $8.84 \pm 5.16\%$ with wrist joint restriction ($p < 0.05$).

In the carrying a cube task, there were changes in the %isolation of the muscles between with and without wrist joint restriction (Table 3). Without wrist joint restriction, the %isolation of the upper trapezius was $24.76 \pm 16.19\%$, and it increased to $40.25 \pm 28.17\%$ in the presence of wrist joint restriction. The change was statistically significant ($p < 0.05$). In contrast, the %isolation of triceps brachii, extensor carpi radialis, and flexor carpi radialis changed from $10.91 \pm 11.71\%$, $18.88 \pm 8.02\%$, and $29.68 \pm 18.16\%$, respectively, in the absence of wrist joint restriction to $5.93 \pm 4.18\%$, $12.50 \pm 5.33\%$, and $22.09 \pm 16.66\%$, respectively, in the presence of wrist joint restriction. The decreases were statistically significant ($p < 0.05$). In the peg-board task, there were changes in the %isolation of muscles between with and without wrist joint restriction (Table 4). Without wrist joint restriction, the %isolation of the extensor carpi radialis was $18.48 \pm 8.27\%$; this changed to $13.96 \pm 5.64\%$ with wrist joint restriction. The %isolation of the flexor carpi radialis changed from $25.93 \pm 19.58\%$ without wrist joint restriction to $18.61 \pm 12.89\%$ with wrist joint restriction. Both the extensor and flexor carpi radialis showed significant decreases ($p < 0.05$).

DISCUSSION

In the grasping, pinching, and peg-board tasks, %isolation of the upper trapezius increased significantly. In the carrying a cube task, the %isolation of the upper trapezius

Table 1. %isolation for the grasping task (Unit: %isolation)

	Muscle	Without Restriction	With Restriction
Grasping	Upper trapezius*	35.57	40.93
	Middle deltoid	11.49	11.95
	Biceps brachii	6.90	6.68
	Triceps brachii	6.80	6.64
	Extensor carpi radialis*	22.75	15.19
	Flexor carpi radialis	16.49	18.61

*p<0.05

Table 2. %isolation for the pinching task (Unit: %isolation)

	Muscle	Without Restriction	With Restriction
Pinching	Upper trapezius*	25.28	39.77
	Middle deltoid	13.93	13.57
	Biceps brachii	6.04	6.35
	Triceps brachii	9.94	9.57
	Extensor carpi radialis*	17.03	8.8
	Flexor carpi radialis	27.78	21.94

*p<0.05

Table 3. %isolation for the carrying a cube task (Unit: %isolation)

	Muscle	Without Restriction	With Restriction
Carrying a cube	Upper trapezius*	24.79	39.28
	Middle deltoid*	7.75	13.29
	Biceps brachii	7.99	6.94
	Triceps brachii*	10.91	5.93
	Extensor carpi radialis*	18.88	12.2
	Flexor carpi radialis	29.68	22.06

*p<0.05

Table 4. %isolation for the peg-board task (Unit: %isolation)

	Muscle	Without Restriction	With Restriction
Peg-board	Upper trapezius	31.93	41.82
	Middle deltoid	11.23	13.47
	Biceps brachii	6.54	7.75
	Triceps brachii	5.89	4.39
	Extensor carpi radialis*	18.48	13.96
	Flexor carpi radialis*	25.93	18.61

*p<0.05

and middle deltoid increased significantly. This is in line with the results of various other studies, which showed that restricted wrist joints increase shoulder movement and muscle fatigue^{11–13}). Mobility of the elbow and hand joints is essential for the effective use of the hand, as well as the stability of the shoulder and elbow joints^{14–16}). Thus, it is thought that wrist joint restriction significantly decreases the stability of the shoulder joints.

In the grasping and pinching tasks, the finger flexors need

to contract. Finger flexors include extrinsic muscles extending from the forearm as well as intrinsic muscles within the palm¹⁷). In the grasping and pinching tasks, the wrist creates a flexion phenomenon because the finger flexor ligaments contract with the finger flexor¹⁸). In this process, the wrist extension muscles are activated to resist wrist flexion in order to maintain wrist stability¹⁹). Thus, it is thought that wrist joint restriction significantly decreases the %isolation of the wrist extension muscles when grasping and pinching

motions are carried out.

In the carrying a cube task, %isolation of the triceps brachii decreased significantly. Pronation and supination of the forearm affects the elbow joint²⁰⁾. In particular, the triceps brachii shows increased muscle activity with pronation of the forearm²¹⁾; for example, picking up and holding objects above a desk, requires pronation of the forearm at 45–95°²²⁾. In other words, forearm pronation increases the muscle activity of the triceps brachii, and wrist joint restriction results in restricted pronation ability of the forearm. As a result, shoulder abduction and elevation increases, whereas the %isolation of the triceps brachii decreases.

There were several limitations to this study. First, the study was conducted with healthy subjects, not persons with wrist joint restriction. Disorders that may cause wrist joint restriction pose other risks in addition to wrist joint restriction alone. Second, this study was limited to subjects who were in their 20's, and biomechanics may change with age²³⁾. The fact that disorders of the wrist might affect different age categories was not considered in this study.

One of the major factors that may affect wrist joint restriction is wearing an orthosis. A wrist orthosis is frequently used to provide wrist stability to those with various musculoskeletal system disorders. It is also indicated that compensation frequently occurs in relation to the use of wrist orthoses. Since those with musculoskeletal system disorders such as arthritis, fracture and carpal tunnel syndrome can return to their daily routine with the aid of an orthosis, it is necessary for the wearers to learn how to manage compensation by themselves. The results of this study may be used as a treatment and education tool, as they provide information on changes in muscle patterns and compensation related to functional activities. Using such information, therapists can predict whether mobility should be facilitated or restricted in order to help and improve the quality of life of those with wrist joint restriction through treatment and educational sessions.

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